LONG-PERIOD (3 TO 10 S) GROUND MOTIONS IN AND AROUND THE LOS ANGELES BASIN DURING THE Mw7.2 EL MAYOR-CUCAPAH EARTHQUAKE OF APRIL 4, 2010

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1. Summary

The Mw7.2 El Mayor-Cucapah earthquake of April 4, 2010 was recorded as many as about 240 strong ground motion stations in and around the Los Angeles (LA) basin that is about 250 km away from the source. This earthquake is the first event providing a large number of high-quality recordings to study spatial variation of long-period ground motion amplification in and around the LA basin. The PGV in the basin reached to 0.12 m/s within a period range of 3 to 16 s. The ground motions in and around the basin were dominated by long-period components; their Fourier acceleration spectra have a peak around 6 s. In this paper, spectral amplification factors of long-period ground motions in and around the LA basin were evaluated with respect to the 17 reference hard-rock sites surrounding the basin. This evaluation has led to the following conclusions:

1. At 8 and 10 s spectral periods, the maximum amplification factor is 5 in the central part of the LA basin, where the Vs 3.2 and 2.8 km/s isosurfaces according to the CVM-H 6.2 are the deepest in the basin.
2. In San Gabriel valley, the maximum amplification factor is 4 at periods of 8, 6 and 4 s, and it is better correlated with the depths to the Vs 1.5 km/s isosurface than the depths to the Vs 3.2 and 2.8 km/s.
3. The largest amplification factor is 10 at a period of 6 s in the western part of the LA basin (Manhattan Beach), where the CVM-H 6.2 failed to provide the feature of underground structures corresponding to this observed high amplification. Manhattan Beach houses many large-diameter oil tanks for which amplified ground motion may adversely affect their seismic performance during a strong shaking.
4. We found a contrast causing the large ground motion amplification between the central part of the LA basin and San Gabriel valley. The large amplification in the central part of the LA basin is considered to be the result of firm but thick sediment relative to the San Gabriel valley, while the high amplification in the San Gabriel valley is considered to be the result of thin but soft sediment relative to the LA basin. This contrast suggests that detailed velocity profile of the sediment should be also considered in addition to the total thickness of sediment or depth to the basin basement for more precise prediction of long-period ground motions.

2. Horizontal Peak Ground Velocity [m/s] (Period Range: 3 to 16 s)

Southern California

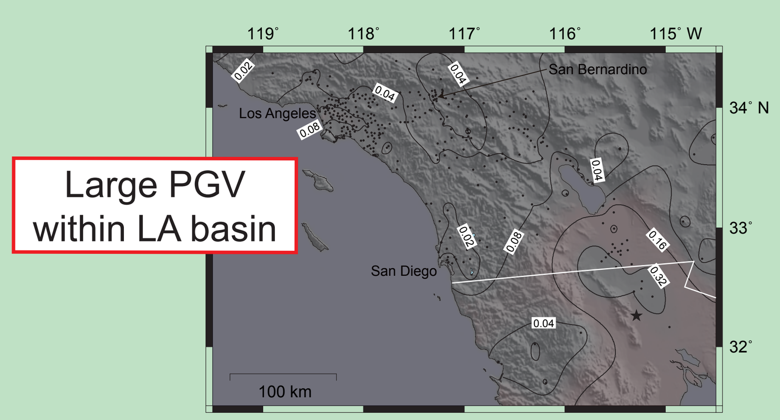


Figure 1. Contour map of the horizontal PGV values (m/s) observed in the southern California during the El Mayor-Cucapah earthquake.

In and Around Los Angeles Basin

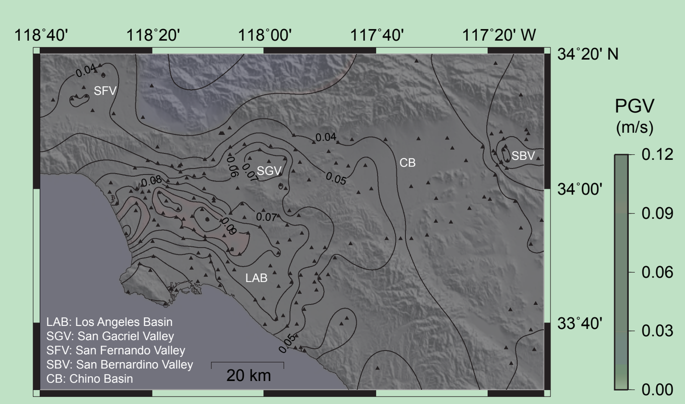
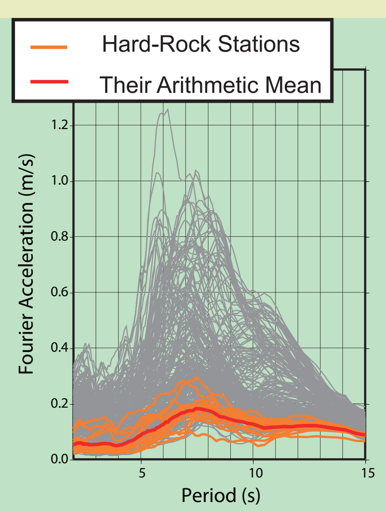


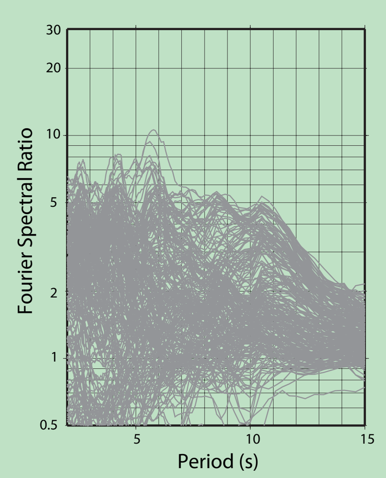
Figure 2. Contour map of the horizontal PGV values (m/s) observed in and around the LA basin during the El Mayor-Cucapah earthquake.

3. Fourier Acceleration Spectra in and around LA Basin



Fourier Acceleration Spectra in and around LA Basin

Figure 3. Fourier acceleration spectra of ground motion data from the stations located in and around the LA basin (Fig. 2). The plotted spectral ordinates are the geometric means of the two-horizontal-component spectra. (Fig. 2) during the El Mayor-Cucapah earthquake.



Fourier Spectral Ratio with respect to Hard-Rock Sites

Figure 4. Amplification factors of the Fourier spectra in and around the LA basin with respect to the reference hard-rock stations surrounding the basin. The amplification factors plotted are the ratio of the Fourier acceleration spectra (the gray lines in Fig. 3) to the one averaged among the reference stations (the red line in Fig. 3).

5. Wave Propagation within LA Basin

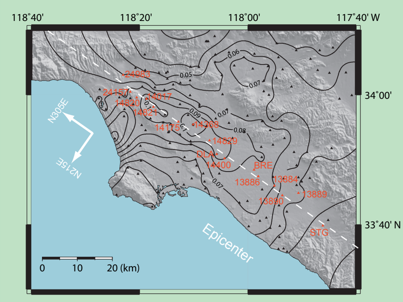


Figure 5. Stations (orange triangles) located on a line (broken line) running from the epicenter through the LA basin. Ground velocity waveforms observed at these stations are shown in Fig. 6.

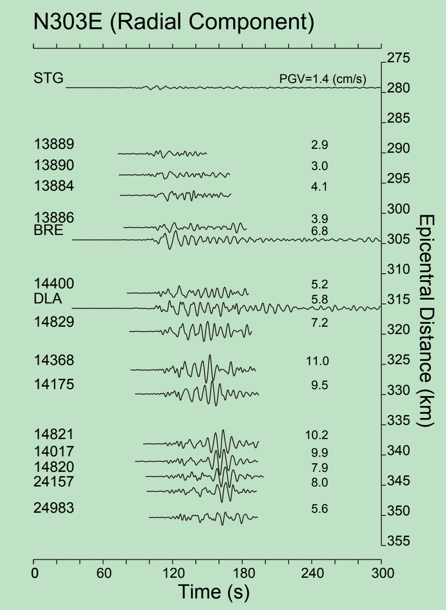


Figure 6. N303°E-component ground velocity waveforms (period range: 3 to 16 s) observed at the stations linearly located on the line running from the epicenter through the LA basin (Fig. 5). This direction corresponds to the radial direction with respect to the one from the source to the basin.

6. Observed vs. Simulated Spectral Amplification Factors

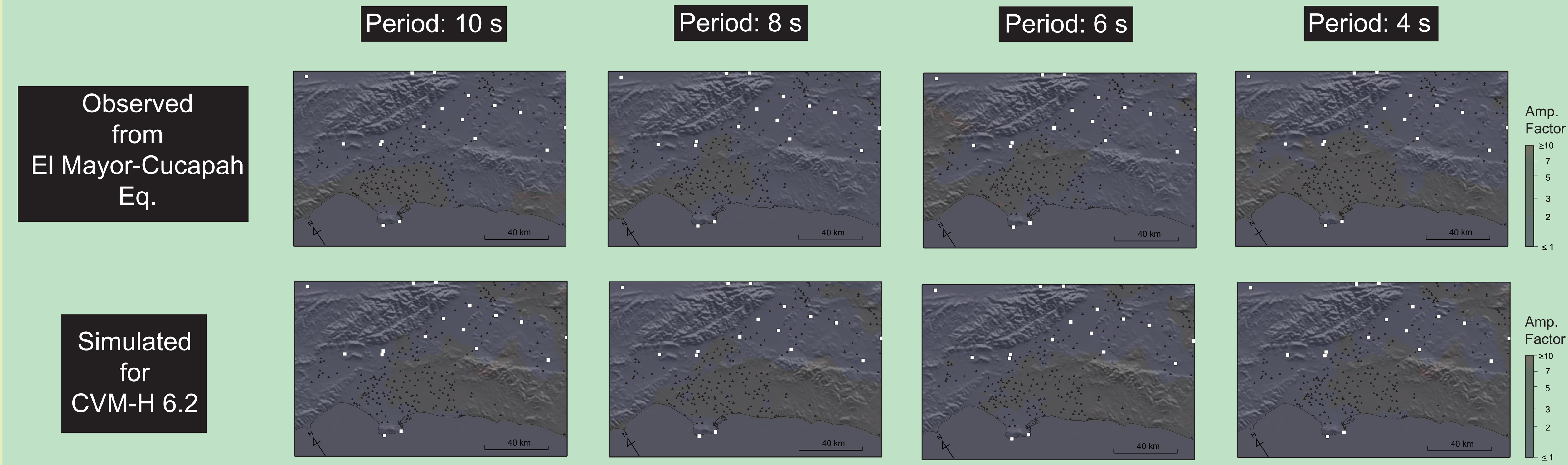


Figure 7. Comparison of period-specific spectral amplification factors in and around the LA basin between (upper) the observation and (lower) the simulation. The amplification factors depicted for the observation are the Fourier spectral ratios shown in Fig. 4. The simulated amplification factors were computed from the wave propagation simulation made for the velocity model of the SCEC CVM-H 6.2.

7. Spectral Amplification Factors vs. Depth to Different Vs-Isosurfaces (CVM-H 6.2)

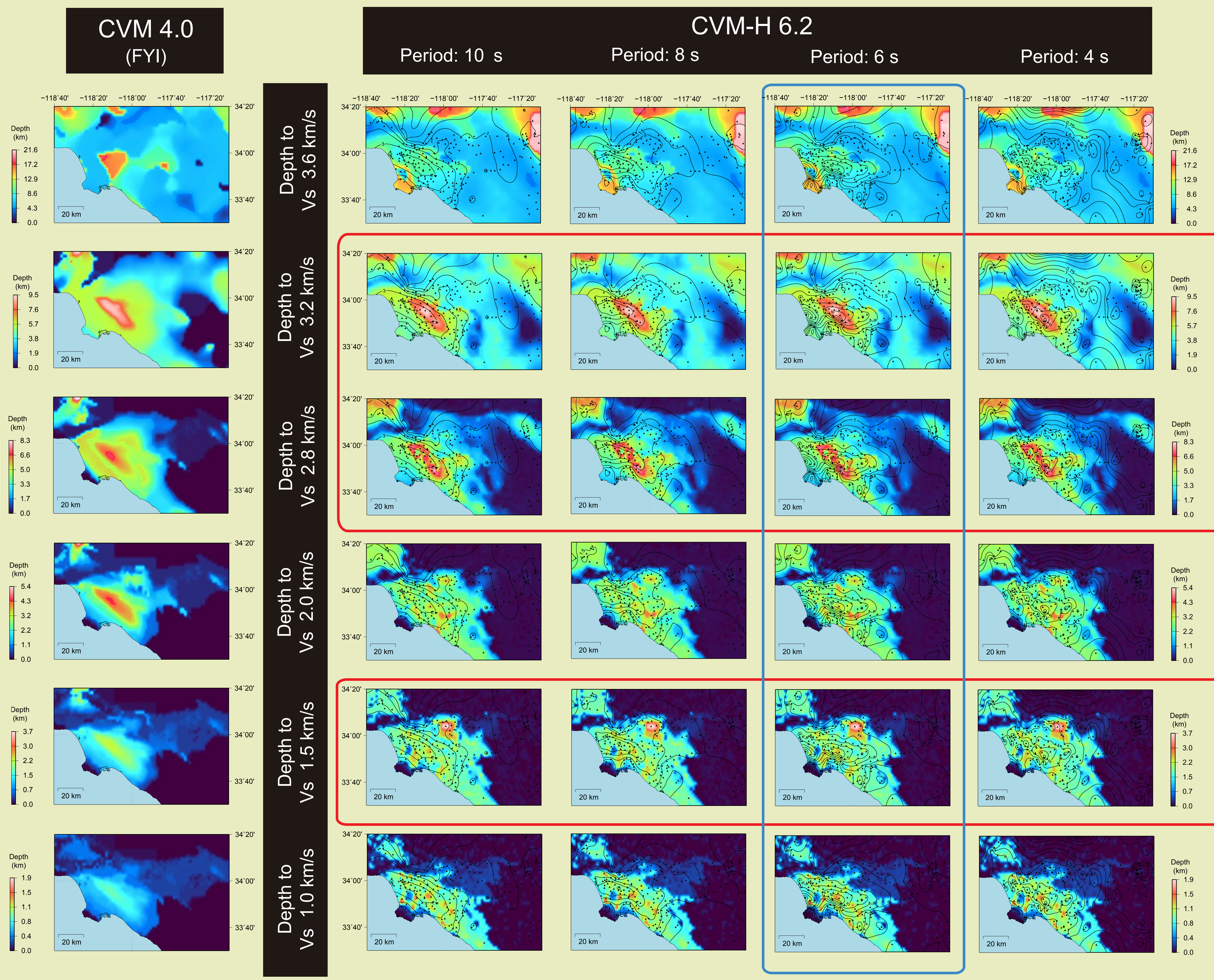


Figure 8. Comparison of period-specific amplification factors (contour lines) with depths (colors) to isosurfaces above which the S-wave velocities are less than a given value. The contour lines of the amplification factors for periods of 10, 8, 6 and 4 s are superimposed onto the six maps showing depths to the isosurfaces above which S-wave velocities (Vs) are less than 3.6, 3.2, 2.8, 2.0, 1.5 and 1.0 km/s. The amplification factors are the ratio of the Fourier acceleration spectra (the gray lines in Fig. 4) to the one averaged among the reference stations (the red line in Fig. 4). The depths to the isosurfaces are after the CVM-H 6.2.

It is suggested that not only the total thickness of sediment or depth to the basin basement, but also the detailed velocity profile of the sediment should be taken into account for more precise prediction of long-period ground motions.

Large amplification occurs in the central part of the LA basin, where the Vs 3.2 and 2.8 km/s isosurfaces are the deepest but the soft (Vs < 1.5 km/s) sediments are thinner than in the San Gabriel Valley.

Central LA basin's large amplification is due to thick but firm sediments relative to San Gabriel valley

Large amplification in the western part of the LA basin (Manhattan Beach) cannot be explained by this basin model.

Large amplification occurs even in the San Gabriel valley, where the soft (Vs < 1.5 km/s) sediments are thicker than in the LA basin but the Vs 3.2 and 2.8 km/s isosurfaces are shallower.

San Gabriel valley's large amplification is due to thin but soft sediments relative to LA basin.